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Assessments of Atlantic salmon stocks of Salmon Fishing Areas 20 and 21, the Southern Upland of Nova Scotia, for 1999.

by

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Abstract

Assessment of the Atlantic salmon (*Salmo salar*) stocks of two Salmon Fishing Areas, SFA 20 on the Eastern Shore and SFA21 on the Southern shore of Nova Scotia indicated that returns in 1999 were insufficient to achieve conservation requirement in any index river. Returns to low-acidified index rivers were only 22% of the adult salmon requirement in the St. Marys River and 48% of the requirement for the area above Morgans Falls on the LaHave River. Generation-to-generation survival above Morgans Falls for the 1994 egg deposition year-class was again below replacement. Smolt to one-sea-winter survival of stocked hatchery smolts continued a declining trend since 1984 to 0.31% while survival to two-sea-winter salmon increased marginally to 0.17%. Wild smolt survival back to Morgans Falls decreased to 2.04%. The ratio of wild to hatchery returns for one-sea-winter salmon was 4.8, 5.0 and 6.6 for the 1996 to 1998 smolt classes. Low return rates to low-acidified rivers further constrain enhancement and restoration programs. Hatchery smolt return rates to partially acidified rivers (mean annual pH 4.7 to 5.0) has declined to 0.05% at East River Sheet Harbour and to 0.03% at Liscomb River. Total salmon count at the Liscomb River fishway was only 25 salmon, and only 33 salmon were counted at East River Sheet Harbour. Tusket River smolt and adult assessment data indicated that the proportion of adult salmon counted in fishways while operating in the assessment mode for a portion of the season was 76.3%. An estimate of 12,408 wild smolts was derived for Tusket River. The high production rate of 48 smolts per escaped salmon indicated that perhaps only the higher pH Carleton River was the origin of the wild smolts. Forecasts to two index rivers indicated a 65% chance of attaining the conservation requirement above Morgans Falls and a 33% chance for St. Mary's River in 2000.

Résumé

Une évaluation des stocks de saumon atlantique (*Salmo salar*) de deux zones de pêche du saumon, ZPS 20 sur la côte est et ZPS 21 sur la côte sud de la Nouvelle-Écosse, a indiqué que les remontées en 1999 ne suffisaient pas à combler les besoins de conservation de chacune des rivières-repères. Les remontées dans les rivières-repères peu acidifiées représentaient seulement 22 % des besoins en saumons adultes dans la rivière St. Marys et 48 % des besoins pour la zone en amont des chutes Morgans, sur la rivière LaHave. Le taux de survie d'une génération à l'autre en amont des chutes Morgans était de nouveau inférieur au remplacement pour la classe d'âge de la ponte de 1994. Le taux de survie des smolts unibermarins est en baisse constante depuis 1984 et s'établit à 0,31 %, tandis que celui du saumon dibermarin a légèrement augmenté pour se fixer à 0,17 %. Le taux de survie des smolts sauvages revenant aux chutes Morgans a diminué pour s'établir à 2,04 %. Le rapport entre les remontées d'unibermarins sauvages et d'unibermarins d'élevage était respectivement de 4,8, de 5 et de 6,6 pour les classes de smolts de 1996 à 1998. Les faibles taux de remontées dans les rivières peu acidifiées ont nui davantage aux programmes de mise en valeur et de rétablissement des stocks. Le taux de remontées des smolts d'élevage dans les rivières partiellement acidifiées (pH annuel moyen de 4,7 à 5) a chuté pour se fixer à 0,05 % dans la rivière East, Sheet Harbour et à 0,03 % dans la rivière Liscomb. Seuls 25 saumons au total ont été dénombrés à la passe migratoire de la rivière Liscomb, et uniquement 33 saumons dans la rivière East, Sheet Harbour. Les données d'évaluation sur les smolts et les adultes de la rivière Tusket ont montré que la proportion de saumons adultes dénombrés dans les passes migratoires pendant le fonctionnement en mode d'évaluation pour une partie de la saison était de 76,3 %. Pour cette rivière, on a calculé environ 12 408 smolts sauvages. Le taux élevé de production de 48 smolts par évadé a indiqué que les smolts sauvages provenaient peut-être exclusivement de la rivière Carleton, qui présente un pH supérieur. Les prévisions pour 2000 pour deux rivières-repères ont révélé que la probabilité de combler les besoins de conservation est de 65 % en amont des chutes Morgans, contre 33 % dans la rivière St. Mary's.

Introduction

Atlantic salmon (*Salmo salar*) rivers in Maritimes Canada have been grouped by the Department of Fisheries and Oceans (DFO) for management purposes into twenty-three Salmon Fishing Areas (SFA) based on similarities of biological characteristics, catch histories and geographical proximity. In Nova Scotia two of these areas, SFA 20 on the Eastern Shore and SFA 21 on the Southern Shore, almost entirely drain a coastal plain geologically known as the Southern Upland (Roland 1982). The number of rivers in the Southern Upland that historically produced Atlantic salmon is unknown but is thought to have included all accessible habitats. Recent salmon production, as indicated by reported recreational catch, includes about forty rivers in these areas (O'Neil *et al.* MS1998).

Rivers of the Southern Upland of Nova Scotia generally drain lowland areas of shallow soils and peat bogs underlain by granites and metamorphic rocks lacking in base minerals (Watt 1987). Water is generally organic-acid-stained of lower productivity and, when combined with acid precipitation these conditions can result in toxic conditions for salmon (LaCroix 1985). Interspersed are areas of limestone-rich soils (drumlins) that provide local areas of less acidified water. Difficulties in identifying the locations and quantifying the degree of impact has impeded the derivation of standard conservation requirements for acidified rivers in these areas of mixed geology.

At mean annual pH below 5.1, salmon production is considered unstable and only remnant populations may persist. Watt (1987), reports fourteen low- or non-acidified salmon rivers in SFA 20 (Gaspereau Brook, West Sheet Harbour, East Sheet Harbour, Port Dufferin, Halfway Brook, Ecum Secum, Quoddy, Moser, Ship Harbour Lake Charlotte, Country Harbour, Saint Mary's, Salmon Guysborough, Musquodoboit and Guysborough rivers) and eight rivers in SFA 21 (Gold, LaHave, Medway, Martins, Meteghan, Musharnush and Petite Riviere). These rivers have a history of Atlantic salmon angling catches and had pH's greater than 5.1.

Two of these rivers, LaHave River above Morgans Falls, Lunenburg County, and St. Mary's River, Guysborough County, were used as indices of the 1999 status of Atlantic salmon in SFA 21 and SFA 20. The count of salmon at Morgans Falls has continued from 1972 and is used to provide in-season forecasts for SFA 20 and 21 (Amiro *et al.* MS1996; Harvie and Amiro MS1998). These counts are indicative of returns to rivers of SFA20 and 21 (O'Neil *et al.* MS1998).

On the Southern Upland of Nova Scotia some twenty rivers have salmon stocks that are partially impacted by acidification. Partial impact occurs where the main-stem mean annual pH is 4.7-5.0 and remnant populations of Atlantic salmon may remain in higher pH tributaries. Evidence indicates that water quality in rivers of the Southern Upland of Nova Scotia has deteriorated or at least has not improved since 1986 (Watt MS1997, Watt *et al.* 1999).

Atlantic salmon are extirpated from fourteen rivers of the Southern Upland of Nova Scotia (Watt 1987 and MS1997). Four of these rivers, East River Sheet Harbour, Mersey River, Clyde River and Jordan River, receive hatchery-reared Atlantic salmon smolts solely to support aboriginal and recreational fisheries.

Three rivers, Liscomb River and Tusket River (partially impacted) and East River Sheet Harbour (re-introduced salmon stock), had operational salmon counting facilities in 1999. The Liscomb River fishway count extends back to 1979 and the East River count periodically back to the 1967. Counts at Tusket River 1979 to 1997 are complete only until July each year. Counts were complete for the entire salmon run of 1998 and 1999. Observations made at these facilities are used to corroborate the counts and forecasts made at Morgans Falls, LaHave River, and to assess the index-river approach.

Hydroelectric power facilities or impoundment for domestic water use also impacts some of these rivers including Tusket, Jordan, Mersey, Medway, LaHave, Indian and Northwest (St. Margaret's Bay), Salmon River Lake Major and East River Sheet Harbour rivers. Two rivers included in SFA 22 but containing salmon with biological characteristics more like SFA 20 and 21 rivers are the Annapolis River and the Gaspereau River, which drain into the Bay of Fundy. Both are impounded for hydroelectric power and have fish passage facilities.

Biological characteristics of SFA20 and SFA21 Atlantic salmon

The majority of Atlantic salmon of SFA 20 and 21 migrates to the sea as two-year smolts and are characterised by returns of mixed age-at-maturity salmon (Anon 1978). Detailed age and size information is collected at Morgans Falls, LaHave River, during population estimates in the St. Mary's River, and during broodstock collections in many rivers of SFA 20 and 21. Based on these data, fish that mature after one winter-at-sea (1sea winter (SW) salmon, small salmon or "grilse") comprise about 70% of the numbers of fish and are about 60% female. On average, egg depositions are contributed equally by 1SW and 2SW salmon in these rivers (P. G. Amiro unpublished data).

Historically there were exceptions to this generalisation, notably Annapolis River, Tusket River, East River Sheet Harbour and St. Mary's River. Stocks in these rivers were noted for large salmon, some of which were identified to be three-sea-winter salmon (Marshall 1986). Ageing of salmon in the returns to counting facilities and in-river assessments indicates that most stocks now have higher proportions maturing and returning after one sea-winter than previously observed (Anon 1978, O'Neil and Harvie 1995). Incidences of multiple-spawning salmon have increased in some, but not all, rivers.

Length-fecundity equations have been determined for three rivers, LaHave, Medway and St. Mary's (P. G. Amiro unpublished manuscript) and are applied to assessed rivers depending on proximity.

Conservation Requirements

Operational conservation requirements have been assigned for two low-acidified rivers, LaHave and St. Mary's (Amiro *et al.* MS1996; O'Neil *et al.* MS1998). These requirements are equivalent to 1,320 fish for the LaHave River above Morgans Falls and 3,155 fish for the entire St. Mary's River.

Conservation requirements have been deferred for management purposes in four rivers: East River Sheet Harbour, Mersey River, Clyde River and Jordan River, because toxicity due to low pH and/or habitat loss has precluded the ability of these rivers to sustain natural production of salmon.

Although several perfunctory estimates of conservation requirements for SFA 20 and 21 rivers have been postulated (Marshall *et al.* MS1992, O'Neil *et al.* MS1998) the remaining rivers of SFA 20 and 21 have no established conservation requirements.

Fishery

Salmon are classified in two size categories for management purposes. Salmon less than 63.0 cm are termed "small salmon" and salmon equal to or greater than 63.0 cm are termed "large salmon".

In 1999 no licensed commercial fishery for Atlantic salmon took place in SFA 20 or 21. Based on a forecast for 1999 that indicated a probability of achieving conservation requirement of 83%, and, after consultation with the Zone Management Committees, the recreational salmon fishery opened for hook-and-release angling by artificial fly in SFA 21 and did not open in SFA 20. The June 15 in-season assessment at Morgans Falls, LaHave River, indicated a probability of 88% attaining the conservation requirement. Based on this in-season forecast, observations at the other salmon counting facilities and, fter consultation with stakeholders,a First Nation food fishery began at Morgans Falls and a recreational retention fishery of one fish per day was initiated in the LaHave River.

First Nation food fishery agreements permitted the harvest of Atlantic salmon in the four acidified rivers of SFA 20 or 21 that were recipient of the stocking of hatchery smolts. Depending on the forecasts and in-season assessments, harvests of hatchery male grilse were conducted at the Morgans Falls fishway in 1999. Harvests at Morgan Falls and in the LaHave River recreational fishery were conducted until the July 6, 1999,assessment. Except for Clyde, Jordan, Mersey and East River Sheet Harbour rivers, all salmon fisheries in SFA 20 and 21 discontinued on July 8, 1999, after the second in-season assessment indicated less than 1% chance of achieving the conservation requirement. Based on further assessments conducted on July 15 and July 30, no further salmon fisheries were opened in rivers of SFA 20 and 21 in 1999.

Status- index rivers

Status for all low-acidified rivers in SFA 20 and 21, which are still capable of producing wild Atlantic salmon, is expected to be similar or worse than the index rivers. Dissimilarities in the status of salmon stocks among rivers of these SFAs may be attributed to the levels of acidification and/or habitat loss and to the level of hatchery supplementation.

St. Mary's River

Adult salmon

Total escapement to St. Mary's River was estimated by an in-river mark-and-recapture in 1997 (O'Neil *et al.* MS1998), in 1998, (Marshall *et al.* MS 1998) and again in 1999.

In 1999, a total of 38 adult salmon was marked at three locations on the West Branch of St. Mary's River on September 21 and 22, 1999. A total of 82 fish was captured and examined at three pools on the West Branch of the St. Mary's River on October 4, 1999. Eight of these fish were previously marked in September. Based on these data the most probable estimate (by sequential Bayesian estimation, Gazey and Staley 19xx) of escapement to the West Branch was 390 fish (90%CL 256 – 915). The West Branch at 55% of the total area of the St. Mary's River requires 1,735 salmon of average biological characteristics. Based on the uncertainty of the estimate, there was only a 0.14% chance that at least 1,735 salmon escaped into the West Branch in 1999.

The salmon conservation requirement for the total St. Mary's River is 3,155 fish. Using the estimate for the West Branch and the proportion of the total salmon habitat found in the West Branch, the total escapement to the St. Mary's River in 1999 was estimated at 709 fish or 22% of the conservation requirement.

Based on the observed biological characteristics of the 112 fish captured during the mark and recapture population estimate (Table 1.), 79% of the escapement was first-time-returning (recruit) grilse (matured after one-sea-winter) which were all less than 63 cm. About 15% of the captured fish, or 63% of the fish greater than 63 cm, were repeat spawning grilse.

Table 1. Age, spawning history, gender, and lengths of Atlantic salmon captured by seining in the St. Mary's River, Guysborough County, during September and October of 1999.

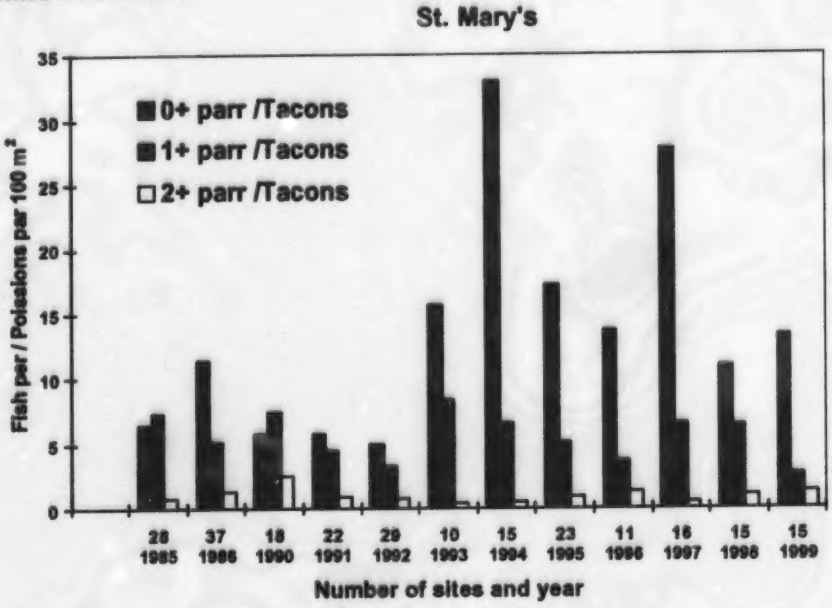
	Number		Length (cm) Mean		Max.		Min.	
Sea age	Males	Females	Males	Females	Males	Females	Males	Females
1	28	57	55.0	54.6	59.5	59.0	51.0	50.0
2 sp 1	1	12	62.2	60.1		63.5		54.0
3 sp 1,2	0	4		67.5		69.5		65.5
2	0	10		75.4		81.0		70.0

The spawning run of fish with these biological characteristics would have contributed about 30% of the required egg deposition for the St. Mary's River in 1999.

Juvenile salmon

Densities of juvenile salmon were determined at 15 sample locations by quantitative electrofishing in 1999. These data indicate an average age-0^+ parr density of 13.3, an age-1^+ parr density of 2.6 and age-2^+ density of 1.4 per 100 m^2. These numbers of parr are low relative to previous annual means and to Elson's "normal index of abundance", i.e., 29 fry, and 38 total older parr per 100 m^2 (Elson 1967). The number of age-1^+ parr resulting from the number of age-0^+ (fry) the previous year was again low. This result continues a trend since 1993 of low fry to parr survival (Figure 1).

Figure 1. Mean densities of age-0^+, -1^+, and -2^+ Atlantic salmon parr determined by electrofishing in 10 to 37 locations of the St. Mary's River. Years of electrofishing and number of locations fished are indicated.



The West Branch mean total age-1^+ and age-2^+ parr density was 1.75 times greater than that estimated for the East Branch in 1999. The West Branch mean total older parr density (age-1^+ and

age-2* parr) was 4.98 ±4.28SD while the East Branch was 2.58 ±1.91SD. This finding could imply that using the estimated salmon escapement for the West Branch with the proportional habitat method might over-estimate the total escapement to the St. Mary's River.

Forecasts of returns to St. Mary's River for year 2000.

Outlook for the St. Mary's River in 1999 was based on the previous five-year mean of estimated escapements and indicated only a 33% chance that returns would be greater than the conservation requirement. Using a similar model to forecast returns in year 2000, based on estimated returns for 1995-1999, forecasts about 1,600 returns or about a 5% chance of achieving the required egg deposition without in-river exploitation.

LaHave River above Morgans Falls

Fishery

The Aboriginal fishery harvested 42 male hatchery grilse at the fishway between June 16 and July 8, 1999.

A preliminary estimate of the recreational fishery harvest was 7 grilse less than 63 cm between June 16 and July 8, 1999. Releases in the recreational fishery were 49 grilse less than 63 cm and 27 salmon equal to or greater than 63 cm between May 10 and July 8, 1999.

Adult salmon counts

The Morgans Falls fishway trap was operated from May 3 to November 5, 1999. Based on the age, size (Table 2.) a total of 435 female salmon was required and only 199 escaped to spawn after removals were accounted (Table 3). The 1999 total count of salmon at Morgans Falls fishway indicated 48% of the requirement of 1,320 fish or 68% of the egg requirement above Morgans Falls were achieved (Figure 2). After broodstock removals and without accounting for non-return fall back, the 1999 potential egg deposition to the river above Morgans Falls was at 55% of the egg deposition requirement.

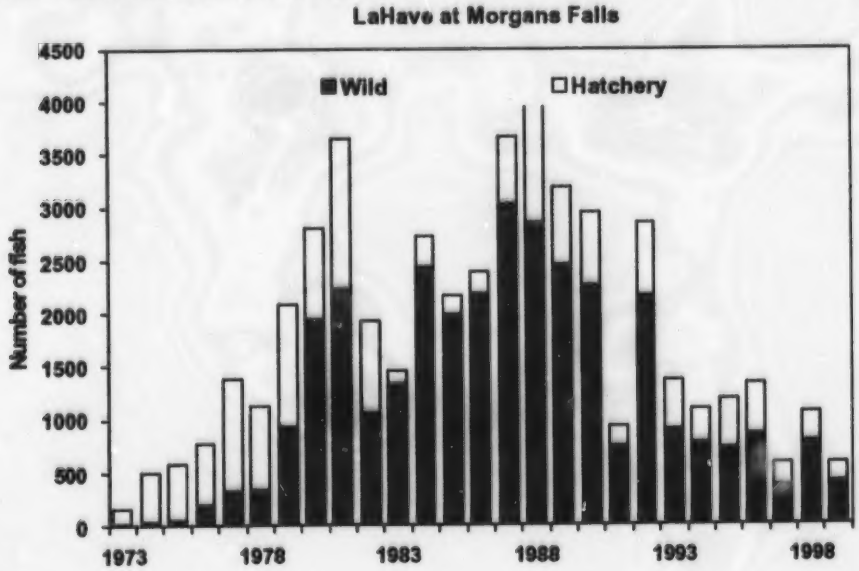


Figure 2. Counts of Atlantic salmon at Morgans Falls fishway identified by smolt origin, 1973 to 1999.

Table 2. Age and size composition of wild and hatchery adult Atlantic salmon sampled at Morgans Falls on the LaHave River, May to November, 1999. Age is shown as years to smolt (fresh), post-smolt years (sea) and ages at previous spawning (s1,s2).

	Age				Fork Length (cm)					Weight (kg)				
Origin	Fresh	Sea	s1	s2	Number	Mean	Min.	Max.	Std. dev.	Number	Mean	Min.	Max.	Std. dev.
Wild														
	1	1			2	57.1	56.4	57.8	0.7	2	2.0	1.9	2.0	0.1
	2	1			126	55.6	50.0	62.5	2.5	126	1.9	1.2	2.9	0.3
	3	1			14	57.3	54.0	63.0	2.6	14	2.2	1.7	2.8	0.3
	4	1												
	2	2			6	75.4	72.7	77.0	1.4	6	5.0	4.1	6.0	0.6
	3	2			72	74.1	65.0	84.0	2.8	72	5.0	3.0	6.9	0.8
	2	2	1		8	61.5	60.3	64.2	1.3	8	2.5	2.1	2.7	0.2
	0	3	1											
	2	3	1		5	77.4	74.3	82.0	2.8	5	6.1	4.5	8.0	1.2
	3	3	1		1	79.3	79.3	79.3	0.0	1	6.5	6.5	6.5	0.0
	2	3	2											
	2	4	2		1	94.0	94.0	94.0	0.0	1	10.5	10.5	10.5	0.0
	2	5	1	3	1	86.5	86.5	86.5	0.0	1	8.6	8.6	8.6	0.0
Hatchery														
	0	1			1	56.5	56.5	56.5	0.0	1	2.0	2.0	2.0	0.0
	1	1			33	56.7	51.0	63.0	3.3	33	2.1	1.5	2.7	0.3
	2	1			4	55.9	53.3	58.0	1.7	4	2.1	1.8	2.3	0.2
	1	2	1		1	64.7	64.7	64.7	0.0	1	3.1	3.1	3.1	0.0
	1	2			35	73.9	68.8	78.3	2.3	35	4.6	3.6	6.8	0.7
	2	2			2	75.4	74.3	76.4	1.1	2	5.1	4.9	5.2	0.2
	1	3	1		2	77.1	74.9	79.4	2.3	2	5.4	3.7	7.1	1.7
	1	3			1	85.5	85.5	85.5	0.0	1	7.1	7.1	7.1	0.0
	0	4	2		1	95.3	95.3	95.3	0.0	1	8.8	8.8	8.8	0.0
	1	4	2		1	87.0	87.0	87.0	0.0	1	8.3	8.3	8.3	0.0

Table 3. Spawning escapement relative to requirements based on numbers of Atlantic salmon counted and aged at Morgan Falls fishway in 1999, removals, size-at-sea-age, fecundity, contribution to egg deposition and required adult salmon. Spawning requirements are based on 1.96×10^6 eggs that at 1,482 eggs per fish is equivalent to 1,320 fish.

Origin Post-smolt age	Gender	Number at age	Prop.	Broodstock removals	Angling+ Native harvest above	Mean length females (cm)	Mean fecundity (eggs)	Eggs contributed	Percent cont. to egg dep.	Required female spawners
Wild										
One-sea-winter	Female	130	0.22	21	0	55.6	3,342	383,874	33.8	198
	Male	188	0.32	29	0	55.9				
Multi-sea-winter	Female	73	0.12	19	0	74.1	6,529	353,309	32.8	98
	Male	14	0.02	6	0	71.3				
Hatchery										
One-sea-winter	Female	50	0.09	4	0	55.9	3,378	155,754	14.5	84
	Male	86	0.15	2	(42)	57.0				
Multi-sea-winter	Female	38	0.06	8	0	75.2	6,794	202,867	18.9	54
	Male	6	0.01	3	0	73.7				
Totals		585	1.00	92	(42)		5,011	1,075,804	100	
Escaped female spawners		291		92	0					199
Required female spawners =										435
Surplus (Deficit) =										(236)

This year was the sixth consecutive that escapement of salmon above Morgans Falls on the LaHave River, before adjustment for non-return fall back, was at or below the operational conservation requirement. However, parr densities have remained average to better than average (Figure 3).

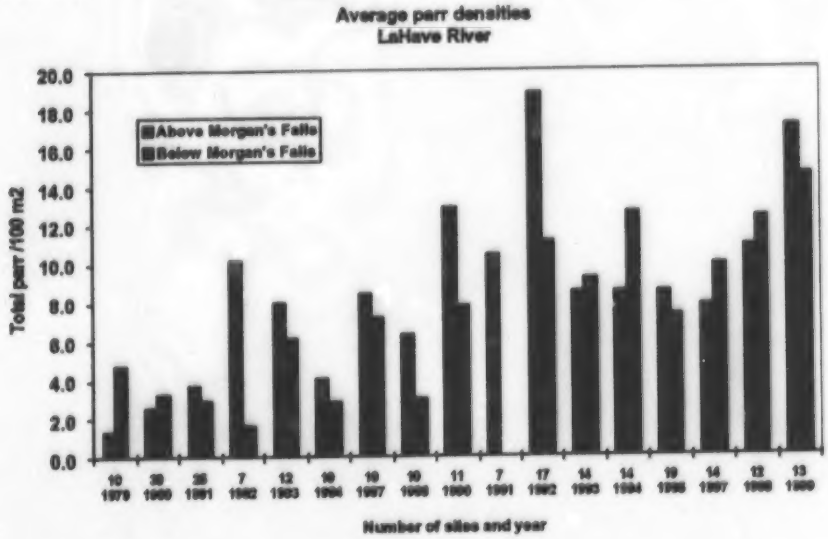


Figure 3. Average density (100 m^2) of age-1^+ and age-2^+ Atlantic salmon parr determined by electrofishing above and below Morgans Falls, LaHave River, 1979 to 1999.

Smolt-to-adult return survival

- Hatchery smolts

Return rate of hatchery smolts to Morgans Falls has continued a declining trend (p=0.001) since 1984. Return rate of 1998 hatchery smolts as 1SW fish in 1999 decreased to 0.31% from the 0.87% experienced in 1998. Returns of 2SW hatchery salmon in 1999 (1997 smolt class) increased to 0.17% from the 0.14% value in 1998 (1996 smolt class)(Figure 4).

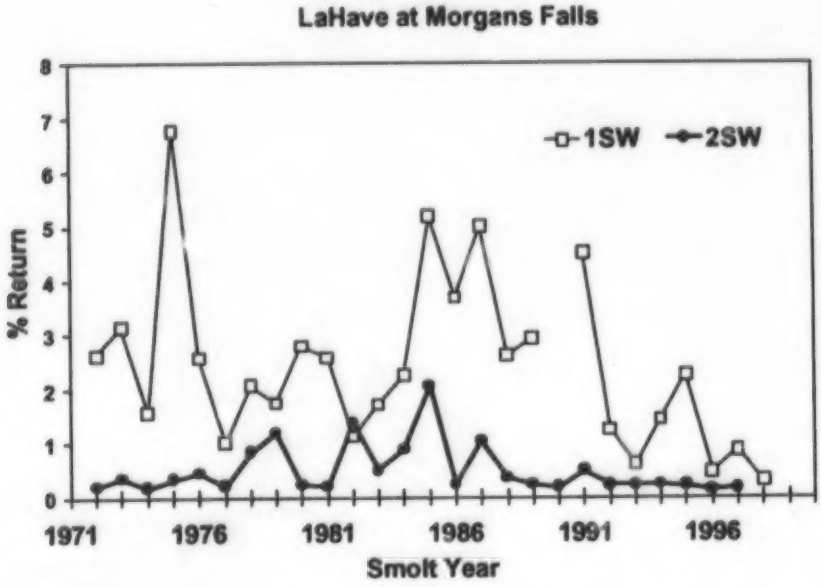


Figure 4. Return rates of Atlantic salmon hatchery-raised smolts released at or above Morgans Falls in the LaHave River, 1972 to 1998.

-Wild smolts

Annual populations of wild smolts have been estimated at the Morgan Falls Power (MFP) facility across from the Morgans Falls fishway since 1996. Known numbers of hatchery-grown smolts are marked and released above Morgans Falls and smolts are captured in the assessment facility below the deflector louvers at the power station. Smolts are counted independent of the operating state of the plant. In 1999 a total 2,700 tagged smolts was released above MFP. A total of 3,799 smolts was examined at MFP of which 782 tagged smolts were recaptured. These data indicated a most probable population of 10,420 (9,760 -11,060, 5th and 95th percentiles) wild smolts in 1999. This number was a decrease from 1998 and from previous years (Figure 5).

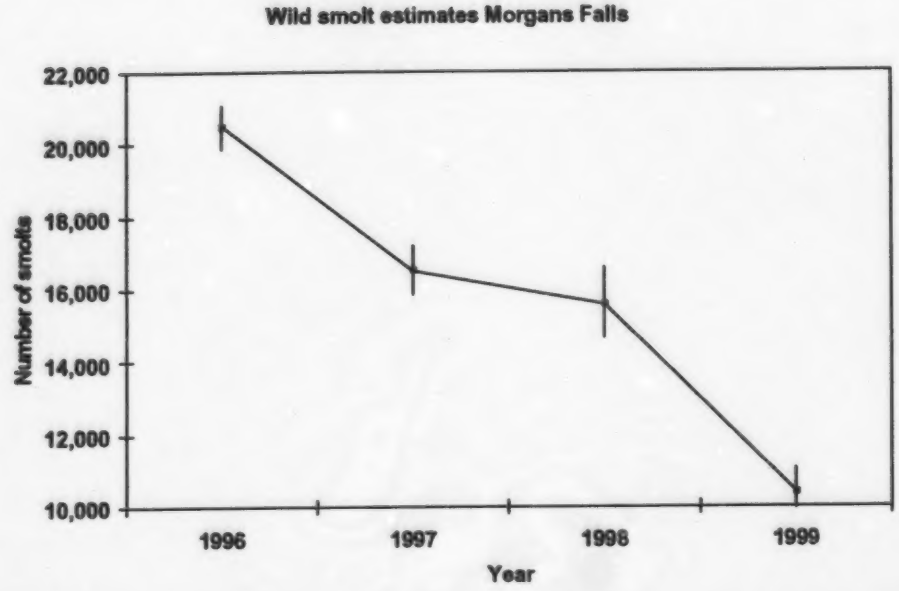


Figure 5. Number of wild smolts and 90% confidence intervals as estimated at the Morgans Falls Power by-pass canal by mark-and-recapture technique for smolts migrating from above Morgans Falls, LaHave River, 1996 to 1999.

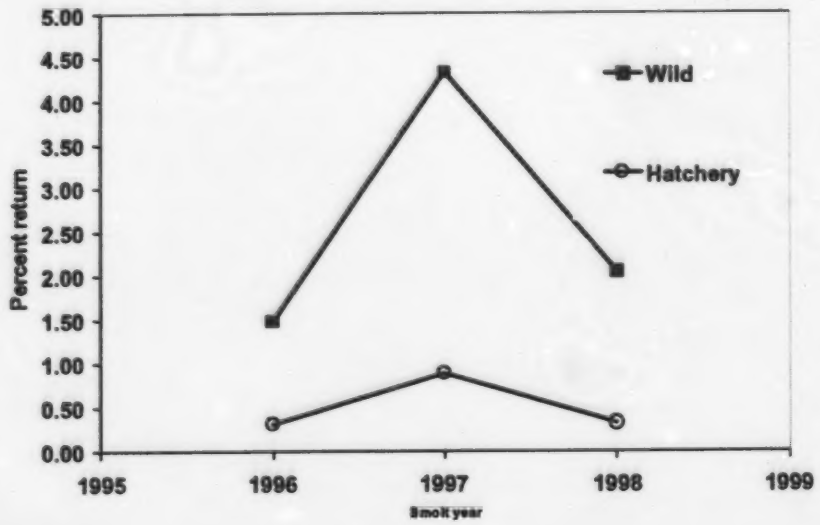


Figure 6. Return rates of wild and hatchery smolts to Morgans Falls after one-sea-winter.

Wild smolt return rate to Morgans Falls for 1998 wild smolts returning as 1SW salmon in 1999 was 2.04%, down from 4.33% observed for the 1997 smolts class (Figure 6).

Returns of wild 1SW salmon and hatchery 1SW salmon provide comparative estimates of return rates for wild and hatchery smolts. This result is because all tagged hatchery smolts were stocked 2.0km above Morgans Falls and all marked hatchery smolts were stocked in the top pool of the fishway. No parr have been stocked above MF since 1994. The ratio of wild to hatchery return rate to the 1SW stage was 4.8 for the 1996 smolt class, 5.0 for the 1997 smolt class and 6.6 for the 1998 smolt class. The ratio to the 2SW stage was 1.9 for the 1996 smolt class and 3.1 for the 1997 smolt class.

Stock and recruitment – Above Morgans Falls, LaHave River

Returns of salmon to LaHave River above Morgans Falls, an area minimally impacted by acidification, have been monitored and aged since 1973. Recruitment is essentially complete after five years, allowing current assessment of the 1994-egg deposition class in 1999. The natural log of the number of recruits for each spawner Ln(r/s), a measure of generation-to-generation survival, has been below population replacement since 1985 and is indicative of a population in decline (Figure 7). Spawners that contributed to recruitment since 1985 have been both high and low, (Figure 8 and 9) yet recruitment has been less than replacement, i.e., Ln(r/s) <1 (Figure 7).

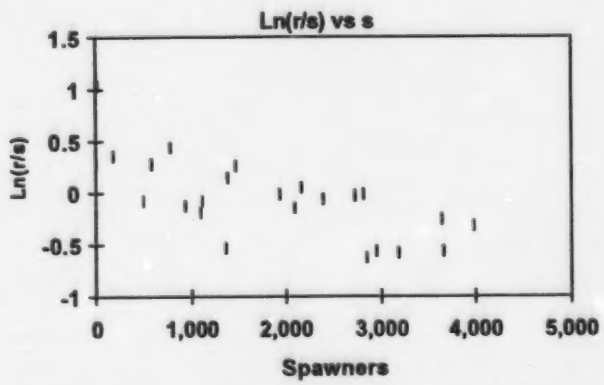


Figure 7. Natural logarithim of the number of recruits from all subsequent years per the number of spawning salmon in that year plotted against the number of spawning salmon.

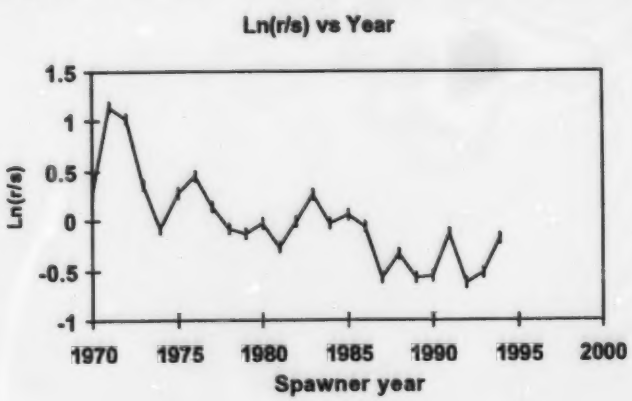


Figure 8. Natural logarithim of the number of recruits from all subsequent years per the number of spawning salmon in that year plotted against the year of the spawning run.

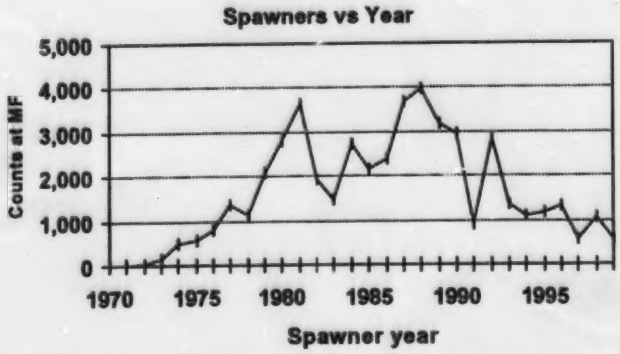


Figure 9. Numbers of salmon counted at Morgans Falls, 1970 to 1999.

Forecasts – LaHave River

Forecast counts to Morgans Falls fishway have been made since 1983. Forecasts are provided for each age-at-maturity (1SW and MSW) and origin (wild and hatchery) classes. MSW (mostly 2SW recruits) are forecast from 1SW counts the previous year. These forecasts are sibling models or first to second recruit models. Hatchery-origin 1SW counts are forecast from known stocking numbers and average or recent return rates. Wild 1SW counts are forecast from annual average counts or from estimated wild smolt output and their various associated return rates. In 1998, three groups of models were shown: A) Long term model averages for the data sets. B) Short term, past five-year averages, for 1SW returns. C) Use of the previous year's return rates for wild and hatchery grilse and the 1999 estimates of wild and hatchery smolts (Table 2).

Although the total count of fish returning in 1999 was not outside the combined 90% CL of Models A, the forecast of hatchery grilse was significantly overestimated by a factor of 4.34. The 1999 forecast of wild MSW count, while not outside the 90%CL was also an overestimate by 1.87 times. These observations are consistent with the trend in Ln(r/s) and indicate a declining trend in marine survival. This trend is not captured in long-term Models A. Models B better capture this downturn. Models C attempt to utilise all of the information at hand and the most recent observed return rates. Variance for return rates used in Models C is that derived from the most recent five (hatchery) and three (wild) year observations.

Because Models B performed better in 1999 and because Models B capture some of the present epoch of low marine survival, it is the recommended model for risk analysis for the year 2000 counts. The models need amendment in order to reflect the higher variation of in-river exploitation during recent years as well as better account for recent survival trends in the data.

Based on Models B, there is a 65% chance of counting the required egg deposition of 1.96×10^6 eggs above Morgans Falls in year 2000 without in-river exploitation. This forecast does not account for non-return fall back (fish that ascend the fishway but fall back down river), which has been estimated between 30 and 40% by two different methods on three occasions.

Table 4. Numbers of Atlantic salmon by stock origin and sea-age composition of returns to the Morgans Falls fishway, LaHave River, 1970 – 1999, forecasts for 2000, and comparison of counts in 1999 with forecasts made for 1999.

Return	Hatchery		Wild		Totals		
Year	1SW	MSW	1SW	MSW	1SW	MSW	Combined
1970	–	–	2	4	2	4	6
1971	–	–	3	–	3	–	3
1972	9	–	8	2	17	2	19
1973	138	9	14	7	152	16	168
1974	442	19	29	2	471	21	492
1975	466	68	38	5	504	73	577
1976	468	108	178	23	646	131	777
1977	974	84	292	25	1,266	109	1,375
1978	567	209	275	67	842	276	1,118
1979	1,064	99	856	67	1,920	166	2,086
1980	336	524	1,648	294	1,984	818	2,802
1981	1,186	232	1,880	349	3,066	581	3,647
1982	623	234	804	257	1,427	491	1,918
1983	25	99	1,118	217	1,143	316	1,459
1984	249	33	2,041	392	2,290	425	2715
1985	105	76	1,348	629	1,453	705	2158
1986	133	78	1,584	589	1,717	667	2384
1987	564	81	2,491	524	3,055	605	3660
1988	1,059	62	2,465	388	3,524	450	3974
1989	442	290	2,053	392	2,495	682	3177
1990	592	110	1,866	382	2,458	492	2950
1991	109	87	499	233	608	320	928
1992	617	60	1,950	217	2,567	277	2844
1993	383	83	788	110	1,171	193	1364
1994	207	119	641	128	848	247	1095
1995	372	85	577	143	949	228	1177
1996	396	81	735	112	1,131	193	1324
1997	144	67	303	68	447	135	582
1998	200	70	720	69	920	139	1059
1999	136	44	318	87	454	131	585
1999 Forecasts A	**591**	**56**	**595**	**171**	**1186**	**227**	**1414**
B	**366**	**56**	**595**	**171**	**595**	**227**	**823**
C	**383**	**56**	**676**	**171**	**1059**	**227**	**1287**
A) 2000 Forecast (long)	**661**	**42**	**1,013**	**96**	**1,674**	**138**	**1,812**
Upper 95th percentile	1418	168	2267	317	3,685	485	4,170
Lower 5th percentile	95	6	0	15	95	21	116
B) Using 5yr. means for wild grilse and 5yr return rates for hatchery grilse.							
2000 Forecast	**317**	**42**	**531**	**96**	**848**	**138**	**986**
Upper 95th percentile	724	168	979	317	1,703	485	2,188
Lower 5th percentile	0	7	82	15	82	22	104
C) Using count of wild and hatchery smolts and 1999 return rates for grilse.							
2000Forecast	**125**	**42**	**213**	**96**	**338**	**138**	**476**
Upper 95th percentile	532	168	226	317	758	485	1,243
Lower 5th percentile	0	6	200	15	200	21	221

Rates and population estimates used:

Hatchery smolt 1998	
Hatchery smolt out=	40,484

Wild smolt estimate 1999	
Mode	10,420
5th	9,760
95th	11,060

Hatchery smolt return (%)			
1999 =	0.310		
Average 1994 - 98 =	0.783	1972-98=	1.634
std. dev. =	0.471		1.070

Wild smolt return (%)	
Mode 1996-1999	2.0385
5th	1.9157
95th	2.1670
1999	2.0439

Table 4. Numbers of Atlantic salmon by stock origin and sea-age composition of returns to the Morgans Falls fishway, LaHave River, 1970 – 1999, forecasts for 2000, and comparison of counts in 1999 with forecasts made for 1999.

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Mode	10,420
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Wild smolt return (%)	
Mode 1996-1999	2.0365
5th	1.9157
95th	2.1670
1999	2.0439

North Branch – LaHave River

A counting trap in the fishway at Indian Falls on the North Branch LaHave River was operated from May 31 to November 10, 1999 the first time a counting trap has been operational at this location since 1983. The fishway provides access above a 4.9m falls that is known to be at least a partial barrier to salmon. All fish that entered the trap at Indian Falls were marked by a lower caudal fin hole punch.

	Number				Mean length cm.		Max. length cm.		Min. length cm.	
	males		females							
Sea age	H	W	H	W	males	females	males	females	males	females
0	0	0	0	1		30.0				
1	17	54	4	34	57.4	56.6	63.5	63.0	51.8	50.0
2	0	3	3	14	73.5	76.0	74.0	80.0	73.1	72.0
3 sp. 1	0	0	0	1		78.0				

Unknown ages:3 H males large, 2 W males large, 4 W males small, 1 W female large, 1 W female small

Totals of 24 hatchery and 107 wild salmon were counted in 1999. This count does not included 42 repeat ascending fish. Included in this number were three grilse previously marked with an upper caudal fin punch at Morgans Falls in 1999. No fish marked at Indian Falls were observed at Morgans Falls fishway in 1999. Also included in the 1999 count at Indian Falls was one tagged grilse known to have been released in New Germany Lake, above Morgans Falls, in 1998.

Two recapture attempts were conducted above Indian Falls, September 24 and October 22, 1999. On the first sampling date only, the pool where the Sherbrooke River crosses the Forties–Dalhousie highway above Sherbrooke Lake was seined. No salmon were caught or observed at this location. On each sampling date the river between Sherbrooke Lake and the outlet of Texas Lake was fished using an electrofishing boat. On September 24 one marked grilse was captured. On October 22 seven marked grilse were captured. No salmon (by sea-age or size) were captured on either of these sampling ocasions although two salmon were observed but not captured.

These data indicate that the count of grilse made at the trap in the indian Falls fishway can be considered a complete count of grilse (<63cm) passing Indian Falls. The same certainty was not established for fish ≥63cm. Salmon were observed jumping at the falls in 1999, and have been previously been observed jumping at the falls.

Musquodoboit River

In 1999 electrofishing for juvenile salmon abundance was conducted at twelve etablished locations in the Musquodoboit River (Figure 10). Densities at these locations remained moderate to high. The Musquodoboit has excellent water quality for salmon, although, ideal habitat for juvenile salmon is limited in comparison to higher gradient rivers. The Musquodoboit has been stocked with Musquodoboit stock smolts and juveniles since 1983.

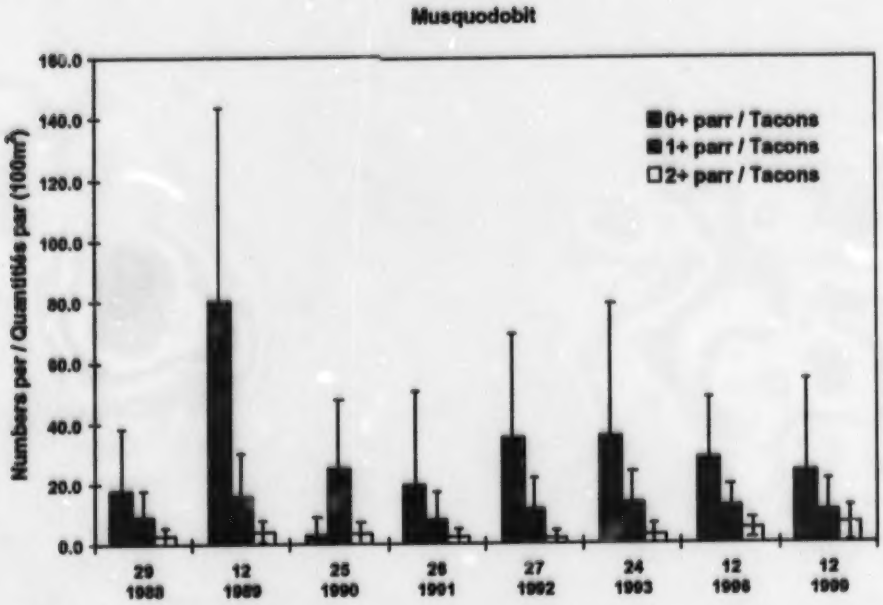

Figure 10. Densities (per 100 m^2 of Atlantic salmon parr age-0^+, 1^+ and 2^+ determined at 12 to 29 locations in the Musquodoboit River 1988 – 1993, 1996 and 1999.

Returns to Musquodoboit River are not monitored other than through recreational fishery lisence stub returns and through observations made while conducting broodstock collections. In 1999 all salmon captured during broodstock collection were retained. This sample indicated 13 wild and two hatchery fish in the collection.

	Number		Length (cm) Mean		Max.		Min.	
Sea age, origin	Males	Females	Males	Females	Males	Females	Males	Females
1, wild	5	0	59.2		61.0		57.0	
1, hatchery	1	0	59.0					
2, wild	0	8		78.1		81.0		71.5
2, hatchery	1	0	79.0					

A final 18 rod days of effort and 15 small and 13 large salmon released were estimated for the June 18 to July 8 season on the Musquodoboit River.

Sackville River

A counting trap in the Cox Fishway at Heffler's Mill was operated from May 18 until November 1, 1999. Including fish removed for broodstock, 22 large salmon and 70 grilse were counted at the trap in 1999.

Forty-one fish were marked and released at the fishway. A total of 24 fish was seined and examined for marks above and below the fishway on October 14 and October 31, 1999. Only one marked fish was recaptured. No reasonable mark and recapture estimate can be derived from

only one recapture. Therefore a minimum population of salmon in the system is the 92 fish counted at the fishway and plus the 23 unmarked fish observed during the seining.

Stock and origin components in the run:

Large Salmon				Grilse			
Male		Female		Male		Female	
Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
2	3	4	13	12	34	14	10

Trap data and the records of broodstock transfers to the hatchery show a discrepancy. Some additional fish (up to 14) may have passed through the trap but are unaccounted.

Ecum Secum River

Ecum Secum River, a low-acidified river, contained sufficient juvenile salmon to enable the derivation of a quantitative density estimate in 1999. One location, site 5, located at the Newchester Road on the main river, was fished in 1999. In comparison to densities determined in 1983 and 1998 (Cameron and Gray 1979, O'Neil *et al.* MS1998), the density of age-0^+ parr increased and the density of older parr decreased.

Location	Age 0^+ / 100 m^2			Older parr / 100 m^2		
site	1983	1998	1999	1978	1998	1999
1	4.9			1.2		
2	4.9			6.5		
3	10.4			9.0		
4	1.8			11.8		
5	0.4	3.3	14.4	17.5	10.3	6.4

Partially-Acidified Rivers of SFA 20 and SFA 21

Liscomb River

Returns to the Liscomb River fishway numbered only 25 fish in 1999 (Figure 11). Wild salmon less than 63.0 cm numbered 9 fish, or 36% of the count.

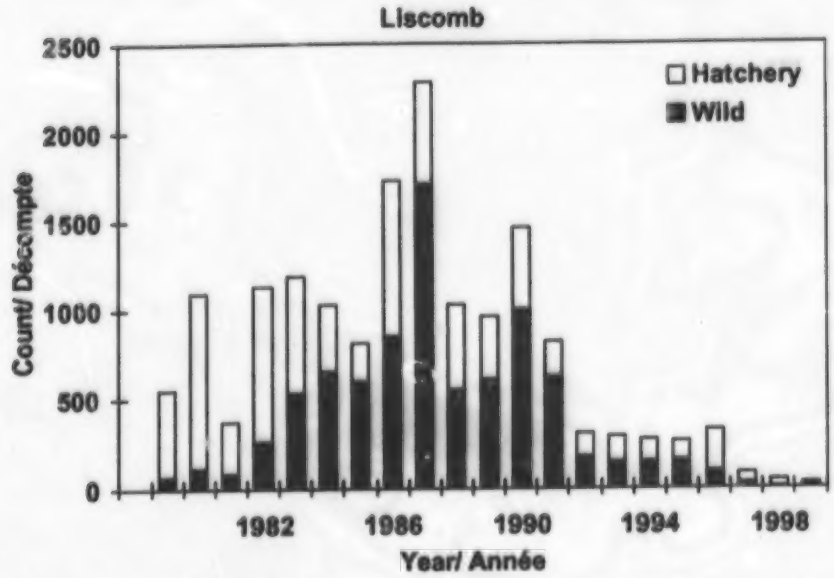

Figure 11. Count of Atlantic salmon by origin at the Liscomb Falls fishway, 1979 to 1999.

Survival of hatchery-origin salmon has declined severely and was only 0.03% to grilse return in 1999. Delayed mortality of stocked smolts attributed to pH shock is suspected, and falling pH (i.e., increased acidity) of the Liscomb River may be the primary cause. Therefore, hatchery supplementation as a mitigation technique for acidification is less effective now in low-pH impacted rivers than when stocking programs began. This effect may be seen in comparison of 1SW return rates for hatchery smolts stocked in LaHave River, a low acid-impacted river, and the Liscomb River, a partially acid-impacted river.

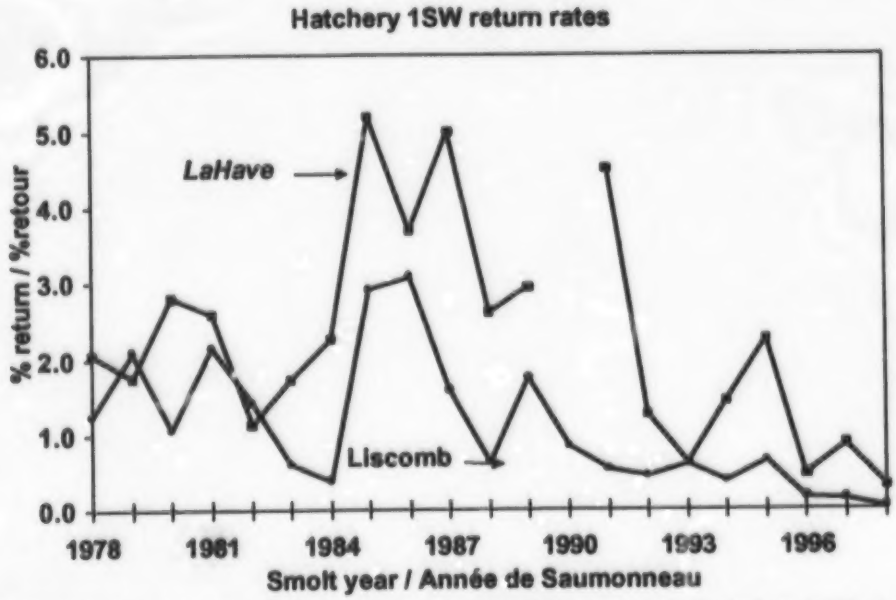

Figure 12. Percent return of hatchery one-sea-winter Atlantic salmon stocked as smots at or above Morgans Falls fishway, LaHave River and to the Liscomb River fishway for smolts stocked 1978 to 1998.

West River Sheet Harbour

Juvenile salmon surveys conducted on the West River, Sheet Harbour, in 1999 continue an intermittent data record back to 1966. No significant increase was noted in the population of age-1^{+} parr above or below a 500m section of the river, which was overlain with limestone rubble in 1996 in order to buffer low pH episodes. In 1999 parr densities increased in both treatment and control locations. Based on the continuing low densities, the declining trend and low abundance of salmon returns to all rivers in the SFA, returns in year 2000 are not expected to be greater than the conservation requirement.

Tusket River

The Tusket River is a hydropower-developed drainage. A diversion dam and powerhouse dam at Tusket Falls, Yarmouth County, creates the Lake Vaughn headpond just above the head of tidal influence. Fishways at both facilities provide upstream access for diadromous fishes. Counts and collection of salmon broodstock have been made at these fishways since 1979. The completeness of these counts is unknown because the fishways were annually open to migration before and after collections were complete and when water levels were low. In 1998 the operating season for these counts was extended to cover the assumed migration season of diadromous fishes known to have been present in the river system. All salmon ascending the fishways in 1998 and 1999 were marked with a caudal fin punch.

In 1999 the downstream passage facility at the powerhouse was modified to sample fish. These samples were examined for marks and tags. Both kelts and smolts were caught and examined. A total of 1,992 tagged hatchery smolts was released on April 21, 1999, to the Carleton River, a higher-pH tributary above Lake Vaughn.

Adult salmon

The count of salmon at the fishways and released to Lake Vaughn in 1998 was 267. A total of 156 kelts was examined in the downstream passage trap from April 8 to May 18, 1999, of which 119 were previously caudal fin pinched. These data indicate that the sampling traps in the fishways in 1998 caught about 76.3% of the population above Lake Vaughn.

The total count of salmon released above the fishways in 1999 was 142 fish.

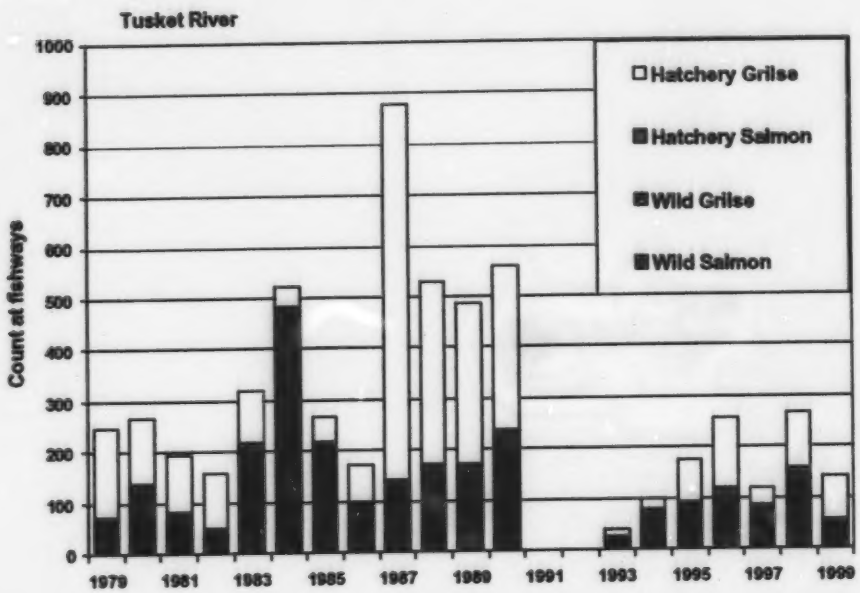

Figure 13. Combined counts of Atlantic salmon summed by size class (grilse < 63.0 cm and salmon ≥ 63.0 cm) and origin of smolt (wild and hatchery) at two fishways of the Tusket River, Yarmouth Co. Nova Scotia, 1979 to 1999.

Smolts

A total of 1,992-tagged hatchery smolts was released in the Carleton River in 1999. Of the 1,501 smolts examined at the downstream by-pass in 1999, 82 were tagged and 1,419 were not tagged. Of the 1,419 smolts without tags, 908 or 64% were adipose fin clipped and therefore derived from hatchery fall fingerling releases. Because not all fall fingerlings were marked before release in 1997, potentially contributing to age-3^{+} smolt in 1999, the proportion of wild smolts in the untagged population is uncertain. A sample of 41 smolts with adipose fins intact was collected in the by-pass in 1999. Scale reading indicated all sampled smolts with an adipose fin intact were of wild origin.

Ages			
1+	2+	3+	Total
1	34	6	41

The above data were used to derive a 1999 modal estimate of 34,458 smolts (90% CL 28,758 – 37,458) not including the tagged smolt release. Of these, an estimated 12,408 had the adipose fin intact and are most likely wild origin smolts. The estimated salmon production area of the Tusket River is 66, 764 x 10^2 m^2, without accounting for pH. The resulting wild smolt production rate for the entire Tusket River above Lake Vaughn in 1999 was 0.186 smolts m^{-2}. The 1996 spawning escapement that contributed 83% of these smolts was 258 adult salmon. These data indicate an approximate production rate of 48 smolts per escaped fish.

Salmon River Digby

Three locations were electrofished in 1999. These locations were previously electrofished in 1978 (Cameron and Gray 1979). The data indicate declines in densities from 1978 to 1999.

Location site	Age 0^+ / 100 m^2		Older parr / 100 m^2		Catch per 5min Age-0^+	Older
	1978	1999	1978	1999	1999	1999
Indian River						
3 (wild)	1.4	3.5	20.2	0.9		
3 (hatchery)				1.1		
Main River						
5	17.1		1.4		0.0	5.0
7	0.0		0.0		0.0	0.0

Other partially acidified rivers of SFA 20 and 21

Electrofishing spot checks were conducted in 1999 on six partially impacted rivers of SFA 20. No wild-origin parr were found in five of these rivers and only a remnant population remains in the Salmon River Port Dufferin.

River	Location	Age-0^+	Older parr
Tangier	Mooseland	0	0
Taylor Bay Brook	above hwy.7	0	0
Salmon R. Port Dufferin	Fourth L. Stills	1	1
Gaspereaux Brook	hwy. 7	0	0
Gegogan Brook	hwy. 7	0	0
Liscomb River	below fishway	0	5 hatchery

Acid-Impacted Rivers with Fisheries Dependent on Stocking

Some rivers can no longer support the production of salmon because of inadequate fish passage, flooding of habitat and acidification. The East River Sheet Harbour, Mersey River, Clyde River and Jordan River receive hatchery smolts placed below barriers and sometimes directly into salt or brackish water to provide adult returns for harvest. Because of low pH there is little natural production possible in these rivers, and therefore no present-day operational conservation requirements are in place. All fish in excess of the broodstock requirements for these stocks have been allocated for exploitation.

Clyde River

Aboriginal or First Nations fisheries reported no effort for 1999. The reported recreational fishery effort was 233 rod-days. The harvest by the recreational fishery was 7 grilse and 2 salmon were reported released (Appendix).

Jordan River

No fishery reported any effort for the Jordan River in 1999 (Appendix).

Mersey River

In 1999 a count of salmon ascending the Cowie Falls fishway on the Mersey River observed only one grilse ascending the fishway. The number of salmon harvested below the fishway is unknown. The estimated recreational catch was four grilse (Appendix).

East River Sheet Harbour

Counts at the Ruth Falls fishway increased to 33 grilse and 3 salmon from a total of 9 fish in 1998. The 1SW return rate of hatchery smolts increased from 0.03% in 1998 to 0.05% in 1999. As was the case in 1998, all fish were retained for broodstock in 1999. As a result of the declining return of ERSH smolts, relative to returns to non-acid-stressed rivers, an experiment to examine the effect of pre-release treated-water acclimation of smolts was begun on ERSH smolts stocked in 1999.

Table 5. Numbers of smolts release, numbers counted at the fishway, return rate and destiny of Atlantic salmon captured at Ruth Falls fishway, East River Sheet Harbour, 1992 – 1999.

		Number of fish counted at fishway[a]						Return rate in percent		Distribution of returns			
	Smolts released	Hatchery		Wild		Total				Released			
Year	year i	1SW	MSW	1SW	MSW	1SW	MSW	1SW yr(i+1)	2SW yr(i+2)	Broodstock	15 Mile Stream	Free swim	Food fishery
1992	26,977												
1993	26,900												
1994	26,700	85	3	17	2	102	5	0.32	0.01	57	24	11	15
1995	36,890	96	4	27	2	123	6	0.36	0.02	57	40	12	18
1996[b]	18,700	135	16	11	1	146	17	0.37	0.06	77	59	14	13
1997[c]	25,740	14	1	4	1	18	2	0.07	0.00	20	0	0	0
1998[c]	33,758	7	1	1	0	8	1	0.03	0.01	7	0	2	0
1999[c,d]	22,020	16	2	15	0	31	2	0.05	0.01	33	0	1	0

a. The barrier dam is passable under high water conditions so these counts are not complete.
b. The barrier dam fish lift was only operated for part of the 1996 run; most fish were captured at the Ruth Falls diversion dam fishway which is located 4 km above the head of tide and above the majority of the angling fishery which harvested grilse. Preliminary angler reports indicate a harvest of 21 grilse; applying the proportion hatchery fish noted at the fishway (0.92) results in 19 hatchery grilse harvested so 135+19= 154, a reconstructed return of 154 fish and a revised return rate of 0.42%.
c. All the trapping was done at Ruth Falls diversion dam.
d. In addition to these numbers there was also one grilse that came from a fall fingerling stocking in 1994.

Management Considerations

Reduced performance of the stocks in low or non-acidified rivers has resulted in management actions in SFA 20 and 21 to decrease in-river exploitation through reductions in recreational fisheries seasons, daily catch limits and early closure of Aboriginal people's fisheries. Based on the status and recent performance of the wild salmon stock above Morgans Falls, LaHave River, and estimates of returns to St. Mary's River, non- or low-acidified rivers are not expected to achieve operational conservation requirements in 2000.

Sixteen rivers in SFA 20 and 21 were stocked with hatchery smolts or parr in 1999 (Table 6).

Table 6. Distribution of hatchery stocked Atlantic salmon smolts and fall fingerlings to rivers of SFAs 20 and 21 during 1999.

River	pH Category	Origin of stock	Number of Smolt	Percent of SFA	Number of parr
SFA 21					
Clyde	1	La Have	11,552	5	
Jordan	1	La Have	4,980	2	
Jordan	1	Medway	0	0	
Mersey	2	La Have	9,960	4	
Sackville	2	La Have	0	0	
Sackville	2	Sackville	20,516	9	26,599
Tusket	2	Tusket	45,457	19	28,292
Gold	3	Gold	16,432	7	
La Have	3	La Have	45,637	19	85,273
Medway	3	Medway	41,640	17	24,854
Salmon River - Digby	3	Salmon River	7,032	3	14,292
Meteghan	4	Tusket	0		14,100
Musharnush	4	La Have	9,545	4	12,900
Petite	4	La Have	10,804	5	12,900
Bear River		Tusket	15,504	6	
SFA 21 Total			239,059		219,210
SFA 20					
East R. Sheet Hbr.	2	East River	22,020	23	4,364
Liscomb	2	Liscomb	56,066	58	23,197
Musquodobit	4	Musquodobit	18,953	20	28,030
SFA 20 Total			97,039		51,227
			336,098		

The St. Mary's and LaHave rivers are representatives of low acid-impacted rivers. Returns to the St. Mary's River in 1999 were again insufficient to achieve the conservation requirement, and are unlikely to be sufficient in year 2000 (5% chance). Also, the conservation requirement was not met on the LaHave River (above Morgans Falls) for the third year in a row and may be achieved in year 2000 (65% chance). The continued trend of low return of hatchery smolts as grilse reduces the expectation that rivers enhanced through hatchery supplementation will have returns in excess of their requirements in year 2000.

The Liscomb River is representative of a partially acidified river. Returns to the Liscomb have shown an almost total loss of wild salmon and a severe decline in the survival of stocked hatchery salmon. Hatchery supplementation as a mitigation technique for acidification is now less effective in these rivers than when stocking programs began. For this reason, despite substantial hatchery smolt stocking in 1998, and 1999, conservation requirements are not likely to be met in 2000 in the Liscomb River or other partially acidified rivers (e.g., Medway, Gold) receiving hatchery supplementation.

Acid-impacted rivers wholly dependent on stocking include the East River Sheet Harbour, Mersey, Clyde and Jordan rivers. Because these rivers are no longer capable of supporting wild salmon production, they have no active conservation requirement. They do, however, offer the potential to provide broodstock to maintain their programs. Considering the low escapements to donor-stock rivers, the self-sufficiency of these programs needs to be considered. The decline in hatchery return rates to all rivers in SFA 20 and 21 and especially to rivers with low pH, indicates that returns in 2000 are not likely to be much greater than broodstock requirements.

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Appendix 1. Atlantic salmon recreational fishing season openings and closings for 1999 in salmon Fishing Area 20

River	SFA	Open	Closed	Comments
Chezzetcook	20	1-Jan	1-Jan	closed
Clam Harbour	20	24-Jun	8-Jul	Hook & release
Cole Harbour	20	1-Jan	1-Jan	closed
Country Harbour	20	24-Jun	8-Jul	Hook & release
East: Sheet Harbour	20	1-Jun	30-Sep	
Ecum Secum	20	18-Jun	8-Jul	Hook & release
Gaspereau: Brook	20	1-Jan	1-Jan	closed
Gegogan	20	18-Jun	8-Jul	Hook & release
Guysborough	20	1-Jan	1-Jan	closed
Halfway Brook	20	1-Jan	1-Jan	closed
Isaac's Harbour	20	1-Jan	1-Jan	closed
Kirby	20	1-Jan	1-Jan	closed
Larry's	20	1-Jan	1-Jan	closed
Lawrencetown Lake (Salmon	20	1-Jan	1-Jan	closed
Liscomb	20	18-Jun	8-Jul	Hook & release
Little Salmon (Lake Major)	20	1-Jan	1-Jan	closed
Moser	20	1-Jan	1-Jan	closed
Musquodoboit	20	18-Jun	8-Jul	Hook & release
Necum Teuch (Smith Bro	20	1-Jan	1-Jan	closed
New Harbour	20	1-Jan	1-Jan	closed
Port Dufferin	20	1-Jan	1-Jan	closed
Quoddy	20	1-Jan	1-Jan	closed
Rocky Run Porters L.	20	1-Jan	1-Jan	closed
Saint Francis	20	1-Jan	1-Jan	closed
Saint Mary's	20	18-Jun	8-Jul	Hook & release
Salmon: Guysborough Co.	20	18-Jun	8-Jul	Hook & release
Salmon: Halifax Co.	20	1-Jan	1-Jan	closed
Ship Hbr.L.Charlotte	20	18-Jun	8-Jul	Hook & release
Tangier	20	1-Jan	1-Jan	closed
Taylor Bay Brook	20	1-Jan	1-Jan	closed
Three Fathom Harbour Brook	20	1-Jan	1-Jan	closed
West Sheet Harbour	20	1-Jan	1-Jan	closed
Porters Lake (East Brook)	20	1-Jan	1-Jan	closed

Appendix 2. **Atlantic salmon recreational fishing season openings and closings for 1999 in Salmon Fishing Area 21.**

River	SFA	Open	Closed	Comments
Barrington	21	1-Jan	1-Jan	closed
Broad	21	1-Jan	1-Jan	closed
Clyde	21	10-May	30-Sep	
East: Lunenburg Co.	21	1-Jan	1-Jan	closed
Gold	21	1-Jan	1-Jan	closed
Ingram	21	1-Jan	1-Jan	closed
Jordan	21	10-May	30-Sep	
LaHave	21	10-May	8-Jul	Hook & release until June 18
Martins	21	1-Jan	1-Jan	closed
Medway	21	1-Jan	1-Jan	closed
Mersey	21	10-May	30-Sep	
Middle: Lunenburg Co.	21	1-Jan	1-Jan	closed
Musharnush	21	18-Jun	8-Jul	daily limit 1
Nine Mile	21	1-Jan	1-Jan	closed
Petite Riviere	21	1-Jan	1-Jan	closed
Roseway	21	1-Jan	1-Jan	closed
Salmon: Digby Co.	21	18-Jun	8-Jul	daily limit 1
Sissiboo	21	1-Jan	1-Jan	closed
Tusket	21	18-Jun	8-Jul	daily limit 1
Sackville	21	1-Jan	1-Jan	closed
Meteghan	21	1-Jan	1-Jan	closed

Appendix 3. Atlantic salmon sportcatch and effort for Scotia-Fundy Region rivers, 1999 and 1998, contrasted with mean catches, 1994-98.

River	1999 Preliminary				1998				1994 - 1998 means							
	Grilse		Salmon		Grilse		Salmon		Grilse				Salmon		Effort	
	retained	released	released	Effort	retained	released	released	Effort	retained	95% C.I.	released	95% C.I.	released	95% C.I.	rodday	95% C.I.
Salmon Fishing Area 20																
Clam Harbour										N/A		N/A		N/A		N/A
Cole Harbour									0	N/A	0	N/A	0	N/A	1	N/A
Country Harbour									7	N/A	5	5	3	N/A	70	N/A
East Sheet Harbour					0	0	0	7	6	16	1	4	0	1	93	134
Ecum Secum									8	14	10	14	2	3	196	136
Gaspereau Brook									0	N/A	0	0	0	N/A	4	N/A
Guysborough									1	N/A	0	0	2	N/A	10	N/A
Halfway Brook									1	N/A	0	N/A	0	N/A	13	N/A
Isaac's Harbour									1	N/A	1	1	0	N/A	17	N/A
Kirby									1	N/A	0	N/A	0	N/A	1	N/A
Larry's										N/A		N/A		N/A		N/A
Lawrencetown Lake									0	N/A	1	1	0	N/A	6	N/A
Liscomb									9	14	6	6	1	1	157	201
Little Salmon									0	N/A	11	N/A	7	N/A	65	N/A
Moser									20	48	19	22	0	0	265	357
Musquodoboit	0	2	2	4	0	13	9	29	34	60	57	105	62	64	711	921
Necum Teuch										N/A		N/A		N/A		N/A
New Harbour									10	16	3	3	0	0	78	99
Port Dufferin									5	N/A	1	1	0	N/A	59	N/A
Porters Lake (East Brook)									0	N/A		N/A		N/A		N/A
Quoddy									0	N/A		N/A		N/A		N/A
Rocky Run Porters Lake									0	N/A		N/A		N/A		N/A
Saint Francis									0	N/A		N/A		N/A		N/A
Saint Mary's	0	0	0	2	0	20	3	16	83	216	176	290	75	93	1296	1760
Salmon: Guysborough Co.	0	0	2	22	0	0	0	0	61	125	130	82	69	72	754	922
Salmon: Halifax Co.									1	N/A	0	N/A	0	N/A	7	N/A
Ship Harbour Lake Charlotte									4	10	1	3	1	3	116	183
Tangier									0	N/A	0	0	0	N/A	3	N/A
West Sheet Harbour					0	1	0	1	0	0	6	12	0	1	19	36
Totals	0	2	4	28	0	34	12	63	219		379		215		3400	

Appendix 4. Preliminary Atlantic salmon sportcatch and effort for SFA 21 rivers, 1998 and 1997, contrasted with mean catches, 1993-97.

River	1998 Preliminary				1998				1994 - 1998 means							
	Grilse		Salmon		Grilse		Salmon		Grilse			Salmon			Effort	
	retained	released	released	Effort	retained	released	released	Effort	retained	95% C.I.	released	retained	95% C.I.	released	rod/days	95% C.I.
Broad										N/A			N/A			N/A
Clyde	7	0	2	233	3	0	5	360	22	16	6	7	7	6	600	263
East: Lunenburg Co.									0	0	0	1	1	1	14	28
Gold									116	67	18	17	35	38	1127	648
Ingram									3	3	2	3	5	10	121	117
Jordan					0	0	0	3	0	0	0	N/A	0	0	2	2
LaHave	7	49	27	226					538	584	143	197	216	124	5876	3382
Martins										N/A		N/A		N/A		N/A
Medway									178	251	17	22	53	34	2447	1258
Mersey	4	0	0	4	3	0	0	428	3	3	0	2	2	3	488	488
Meteghan									1	NA	8	8	4	NA	74	NA
Middle: Lunenburg Co									6	7	3	2	0	1	25	28
Musquash	0	0	0	2					9	11	1	2	1	1	78	111
Nine Mile										N/A		N/A		N/A		N/A
Petite Rivière	2	0	0	22					47	52	9	13	16	5	488	228
Sackville					0	3	0	15	17	28	20	48	3	8	345	462
Salmon: Digby Co.									35	57	3	8	NF	28	288	280
Tusket	9	2	9	54					47	55	13	14	26	25	680	373
Totals	29	51	29	541	6	3	5	609	818		196		368		10117	